

Origami

Big Ideas

Unit of Instruction

Origami – Sonobe Unit and Sonobe Cube created by Mitsonobu Sonobe

Geometry Concepts

- Lines, intersections, shapes, and spatial visualization

Rationale

This origami project will enhance students' understanding of two- dimensional polygons as well as their problem solving skills to create three-dimensional shapes from a flat two-dimensional surface.

NCTM 9-12 Standards

- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.
- Apply transformations and use symmetry to analyze mathematical situations.
- Use visualization, spatial reasoning, and geometric modeling to solve problems.
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
- Use the language of mathematics to express mathematical ideas precisely.

Idaho Content Standards

- G.4.1.1 Analyze properties and determine attributes of two- and three-dimensional objects.
- G.4.1.2 Explore congruence and similarity among classes to two-dimensional objects and solve problems involving them.
- 9-12.VA.1.1.1 Identify representative visual works of art from a variety of cultures and historical periods.
- 9-12.VA.3.3.1 Plan and produce a work of art applying media, techniques, and processes with skill, confidence, and sensitivity.

| Background | |
|---|------------------|
| Vocabulary | |
| Math | Origami |
| Angle bisectors | Color side down |
| Conjectures | Color side up |
| Constructions | Fold and crease |
| Midpoint | Insert in pocket |
| Parallel lines | Mirroring |
| Parallelograms | Modular pieces |
| Perpendicular bisectors | Mountain fold |
| Perpendicular lines | Rotate |
| Polyhedra | Sonobe |
| Reflection | Squash fold |
| Segment bisectors | Turn over |
| Stellated icosahedron | Valley fold |
| Stellated octahedron | |
| Stellated tetrahedron (cube in this project) | |
| Symmetry | |
| Tiling | |
| Math Instruction (pre- or post-project) Pre-project Instruction Basic concepts of origami: vocabulary, symbols See examples of common symbols used in origami at the following websites: http://library.thinkquest.org/5402/terms.html http://members.tripod.com/~PeterBudai/Origami/Symbols_en.htm http://www.geocities.com/Rachel_Katz/origami/symbols.htm | |

Driving Question

Project Objective

Construct a Sonobe Cube using six congruent Sonobe Units.
Research student selected Sonobe unit and modular origami constructions.

Questions to be Answered

How do misinterpreted directions lead to problems with your final product?

If you fold the wrong side (right vs. left) in step 5, page 8, will the unit still work? If you make six mirror units will they still work to make a cube?

Which geometric shapes did you recognize while you were folding? (squares, triangles, what kind of triangles)

What kind of symmetry does a Sonobe Unit have?

How do these Sonobe Units relate to tessellations?

What kinds of polyhedra can be constructed with Sonobe Units? What types of symmetry does each have?

How many Sonobe Units are needed to construct each polyhedron? Compare the number of Sonobe Units required in the each form. What patterns are apparent? [Hint: patterns may be easier to find if you count in 3-unit blocks and think about how they relate to regular polyhedra.]

A polyhedron is said to be n -colorable if it can be made with no two adjacent units in the same color when you use n colors of paper. Which Sonobe polyhedron is 2-colorable? 3-colorable? 4-colorable?

Questions from the following website: (Math on the Street Project)

www.math.serenevy.net/?page=origami/challenge

Materials

Materials Required

Square Paper: Many types of square paper can be used. Here is a short list of paper types that work well.

- Origami Paper
 - www.asianfoodgrocer.com has very inexpensive origami paper
- Patty Paper (also called wax serving paper).
 - Can be found at restaurant supply stores or online.
- 12 x 12 Scrapbook Paper
 - Can be found at any scrapbook supply store
- Magazine paper cut into squares
- Regular notebook or printer paper cut into squares
- Square sticky notes

A device to crease the folds.

- Popsicle sticks, tongue depressor, bone folder, student ID cards, etc

References

CloudRunner Inc. *Origami: The Secret Life of Paper* (Interactive CD). Salinas, CA: Cassady & Greene, 1984.

Fuse, T. *Unit Origami: Multidimensional Transformations*. Tokyo, Japan: Japan Publications, 1990.

Kawamura, M. *Polyhedron Origami for Beginners*. Tokyo, Japan: Kawamura & Nihon Vogue Co., 2001.

Neale, R. & Hull, T. *Origami Plain and Simple*. New York: St. Martin's Press, 1994.

Simon, L., Arnstein, B., & Gurkewitz, R. *Modular Origami Polyhedra*. New York: Dover Publications, 1999.

Franck, Betsy. *Unfolding Mathematics with Unit Origami*. Key Curriculum Press, 1999.

Great site for how to fold unit and how to put them together into polyhedra

<http://roberttgasperson.com/articleblog/2007/08/19/how-to-fold-origami-how-to-make-the-sonobe-module-unit/>

Good diagrams of folding basic sonobe unit and putting two units together:

<http://www.math.lsu.edu/~verrill/origami/sonobe/>

Good diagrams of sonobe unit assembly into polyhedra:

http://www.akpeters.com/previews/Mukerji_Excerpt.pdf

Assembly of sonobe cube: <http://britton.disted.camosun.bc.ca/origami/sonobe.html>

There are also some good videos on YouTube

For example: <http://www.youtube.com/watch?v=XcxJLScCyEo&feature=related>

Lesson Outline

Day One

- Teacher demonstrates how to fold a basic Sonobe unit as students follow along with their own paper. During this process, the teacher should introduce origami terms, symbols, and types of folds (10 minutes)
- Students practice folding a basic Sonobe unit until they have correctly folded 6 units. (15-20 minutes).
- Once all students have correctly folded 6 basic Sonobe units, teacher demonstrates how 3 units can fit together to form one “corner” of the cube (5 minutes).
- Students practice forming “corners”. Then have students try and assemble 2 of the “corners” together to form a cube (10-20 minutes).

Day Two

- Teacher has 6 basic Sonobe units prepared. Teacher or a student revisits how 3-unit corners are constructed, and how 2 of the “corners” can be assembled together to form a cube (5 min).
- Take cube apart and teacher demonstrates how to assemble the “corners” so that they become stellated faces of larger polyhedra (refer to octahedron/icosahedron assembly directions) there must be pictures and directions included in the materials for this to work (5 min).
- Have students decide if they want to make a stellated octahedron (requires 12 units) or a stellated icosahedron (requires 30 units). Allow students to fold Sonobe units and attempt to assemble into the polyhedra of their choice (30 min).

Day Three

- Finish cubes. Work with students who are still struggling...don't give up.
- Analyze folds and the piece as a whole.
- What do you see?
- What creates the structural strength?
- Choose topics for research including all origami and further Sonobe Units (optional).
- Begin research on extension project (optional).

Assessment

Rubric

Sonobe Cube (100 points possible)

Neatness: 20 points

Problem Solving (fixing any incorrect steps): 20 points

Accuracy: 60 points

Optional Research Paper/Project (100 points possible)

Technical Writing: 10 points

Creativity: 20 points

Exploration: 20 points

Content: 50 points

Optional Student Driven Class Demonstration of Research Project (100 points)

Peer Assessment: 50 points

Teacher Assessment: 50 points

Ideas for Further Independent Student Projects

This could easily expand into a senior project.

Modular Origami research.

Kirigami research.

Research on Mitsonobu Sonobe.

Complex origami units.

Extension: Demonstrate advanced Sonobe unit. Note: this is a VERY neat variation on the basic fold and is a worthwhile extension as it makes the polyhedra really “pop”.

- Teacher demonstrate advanced fold as students follow along with their own paper. Once teacher and/or students have successfully folded 3 units, demonstrate how advanced units assemble to form stellated faces (10 minutes).

Origami is the Japanese art of paperfolding. This project focuses on unit origami. Each unit is made with one piece of paper. Then these are put together with many units folded the same way and assembled in various ways to create different geometric shapes. This unit fold was designed by Sonobe Mitsurobu, and thus is called the Sonobe Cube.

Take care to make crisp folds. Your patience here will make assembly easier and the final object will be much neater in appearance.

Mitsunobu Sonobe is an origamian who created the popular [Sonobe Module](#), which she used to make a simple 6-unit cube in [modular origami](#). Later, [Kunihiko Kasahara](#) used the Sonobe module to discover many other regular and semiregular [polyhedra](#), some requiring up to 900 Sonobe units to complete. These Sonobe-module polyhedra are published in *Origami for the Connoisseur* by Kunihiko Kasahara and Toshie Takahama. Japan Press, 1998. [ISBN 4-8170-9002-2](#)

MY DEFINITION OF A SONOBE:

A Sonobe is a unit that has all of the following properties:

- has two points or inserting tabs
- has two pockets (where points go in)
- two units can lock into each other to form a flat module

Origami Glossary

This page contains definitions for many of the terms used in origami design. The contents are adapted and expanded from Origami Design Secrets.

A

Active path: a path whose length on the crease pattern is equal to its minimum length as specified by the tree graph.

Active reduced path: a reduced path within a universal molecule whose length on the crease pattern is equal to its minimum length as specified by the tree graph.

Arrowhead molecule: a crease pattern within a quadrilateral that consists of a Waterbomb molecule combined with an angled dart; it allows an arbitrary four-circle quadrilateral to be collapsed while aligning the four tangent points.

Atom: a portion of a crease pattern that corresponds to a segment of a single flap within a molecule.

Axial crease: a crease in a crease pattern that lies along the axis in the folded form of a uniaxial base.

Axial polygon: a polygonal region of paper in a crease pattern outlined by axial creases. In the folded form, the entire perimeter of an axial polygon lies along the axis of the base.

Axis: a line on a base along which the edges of flaps lie and to which the hinges of flaps are perpendicular.

B

Base: a regular geometric shape that has a structure similar to that of the desired subject.

Bird Base: one of the Classic Bases, formed by petal-folding the front and back of a Preliminary Fold.

Blintzing: folding the four corners of a square to the center

Blintzed base: any base in which the four corners of the square are folded to the center prior to folding the base.

Branch edge: in a tree graph, an edge that is connected to two branch nodes.

Branch node: in a tree graph, a node connected to two or more edges.

Branch vertex: a point in the crease pattern that corresponds to a branch node on the tree graph.

Book symmetry: the symmetry of a crease pattern that is mirror-symmetric about a line parallel to an edge and passing through the center of the paper.

Border graft: modifying a crease pattern as if you added a strip of paper along one or more sides of the square in order to add features to the base.

Box pleating: a style of folding characterized by all folds running at multiples of 45° , with the majority running at multiples of 0° and 90° on a regular grid.

C

Circle/river method: a design technique for uniaxial bases that constructs the crease pattern by packing nonoverlapping circles and rivers into a square.

Circle: the geometric shape within a circle-packed crease pattern that represents a leaf edge in the tree graph. That is, the circle identifies the minimum paper that must be allocated for a free flap.

Circle packing: placing circles on a square (or other shape) so that they do not overlap and their centers are inside the square.

Classic Bases: the four bases of antiquity (Kite, Fish, Bird, and Frog) that are related by a common structure.

Closed sink fold: a sink fold in which the point to be sunk must be popped from convex to concave; it cannot be entirely flattened.

Collapse: the general term for bringing together a large number of creases at once to form a base.

Composite molecule: a molecule that contains axial creases in its interior.

Corner flap: a flap whose tip comes from one of the corners of the square.

Crease: a mark left in the paper after a fold has been unfolded.

Crease assignment: determination of whether each crease is a mountain fold, valley fold, or flat (unfolded) crease. Also called crease parity.

Crease pattern: the pattern of creases left behind on the square after a model has been unfolded.

Crimp fold: a fold formed by two parallel or nearly parallel mountain folds and valley folds on the near layers of a flap with their mirror image folds formed on the far layers.

Crystallization: the process of fixing the locations of circles in a circle packing by enlarging some of the circles until they can no longer move.

Cupboard Base: a traditional base consisting of a square with two opposite edges folded toward each other to meet in the middle.

D

Decreeping: rearranging several trapped layers of paper so that no layer is wrapped around another.

Detail folds: folds that transform the flaps of a base into details of the finished subject.

Diagonal symmetry: the symmetry of a crease pattern that is mirror-symmetric about one of the diagonals of the square.

Dihedral angle: the angle between the two surfaces on either side of a crease, defined as the angle between the surface normals.

Distorted base: a modified base formed by shifting the vertices of the crease pattern so that the paper can fold flat; the number of creases and vertices remains the same, but the angles between them change.

Double-blintzing: folding the four corners of a square to the center twice in succession.

Double rabbit-ear fold: a fold in which the creases of a rabbit ear are made on the near layer of a flap and the mirror-image creases are made on the far layer.

Double sink fold: two sink folds formed in succession on the same flap.

E

Edge: in a tree graph, a single line segment. Each edge corresponds to a unique flap or connector between flaps in the base. See leaf edge, branch edge.

Edge flap: a flap whose tip comes from one of the edges (but not a corner) of the square. An edge flap has twice as many layers as a same-size corner flap.

Edge weight: a number assigned to each edge of a tree graph that represents the length of the associated flap.

Efficiency: a measure of how much paper is used to obtain features of the subject versus extra paper that is merely hidden away.

Elias stretch: A maneuver used in box pleating to create flaps from a pleated region of paper, by changing the direction of the pleats by 90° within wedges of paper.

F

Fish Base: one of the Classic Bases, formed by folding all four edges of a square to a common diagonal and gathering the excess paper in two flaps.

Flap: a region of paper in an origami shape that is attached only along one edge so that it can be easily manipulated by itself.

Folded edge: an edge created by folding.

Four-circle quadrilateral: a quadrilateral formed by connecting the centers of four pairwise tangent circles; such a quadrilateral can be folded so that all edges lie on a line and the tangent points between pairs of circles touch.

Frog Base: one of the Classic Bases, formed by squash- and petal-folding the four edges of a Preliminary Fold.

G

Generic form: a crease pattern within a molecule or group of molecules in which (a) all axial creases are shown as mountain creases; (b) all ridgeline creases are shown as valley creases; and (c) all hinge creases are shown as unfolded creases. The generic form is an approximation of the actual crease pattern of a folded base.

Grafting: modifying a crease pattern as if you had spliced into it a strip or strips of paper in order to add new features to an existing base.

Grafted Kite Base: a family of bases composed by adding a border graft to two sides of a Kite Base.

Gusset: one or more narrow triangles of paper, usually formed by stretching a pleat or crimp.

Gusset molecule: a crease pattern within a quadrilateral that resembles a partially stretched Waterbomb molecule with a gusset running across its top. The gusset molecule, like the arrowhead molecule, allows any four-circle quadrilateral to be collapsed while aligning the tangent points.

H

Hex pleating: a design technique similar to box pleating but that uses triangles, hexagons, and hexagonal rivers for packing and all creases run at multiples of 30° . Occupies a role halfway between circle packing and box pleating in terms of both efficiency and regularity.

Hinge: a joint between two flaps.

Hinge creases: creases that in a uniaxial base are perpendicular to the axis. Hinge creases define the boundaries of flaps or segments of a base.

Hole: a region of paper in a box-pleated crease pattern that does not belong to any atom.

Hybrid base: a base that is constructed using multiple design techniques.

Hybrid reverse fold: a more complicated form of reverse fold that combines aspects of both inside and outside reverse folds.

I

Ideal split: a technique for splitting a Kite Base flap, which gives the longest possible pair of flaps.

Inflation: the process of adding circles to a crease pattern (corresponding to adding flaps to a base) and expanding the circle (lengthening the flap) until it touches 3 or more others. Inside reverse fold (page 25): a method of changing the direction of a flap, wherein the moving layers are inverted and tucked between the stationary layers.

Inside reverse fold: a way of changing the direction of a flap in which the moving layers are inverted and pushed between two of the layers of the flap.

J

K

Kite Base: the simplest of the Classic Bases, formed by folding two adjacent edges of a square to the same diagonal.

L

Leaf edge: in a tree graph, an edge connected to at least one leaf node.

Leaf node: in a tree graph, a node connected to only a single edge.

Leaf vertex: a point in the crease pattern that corresponds to a leaf node on the tree graph.

M

Middle flap: a flap whose tip comes from the interior of the square. A middle flap has twice as many layers as a same-sized edge flap and four times as many as a corner flap.

Mixed sink fold: a sink fold containing aspects of both open and closed sinks.

Molecule: a crease pattern which when folded flat has its perimeter lie along a common line and for which specified points along the perimeter (the tangent points) become coincident in the folded form.

Mountain fold: a crease that is concave downward. Usually indicated by a dot-dot-dash line in sequential diagrams or a solid black line in crease patterns.

N

Node: in a tree graph, an endpoint of a line segment. See leaf node, branch node.

O

Offset base: a modified base formed by shifting the entire crease pattern on the square while preserving angles between creases, so that extra paper is created in some locations while others lose paper.

Open sink fold: a sink fold in which the point to be sunk can be entirely flattened during the course of the sink.

Origami: the art of folding paper into decorative shapes, usually from uncut squares.

Origami sekkei: see technical folding.

Ortholinear river: the analog of a river in box-pleated designs. The river has constant vertical and horizontal width and bends only at 90° angles.

Outside reverse fold: a method of changing the direction of a flap, wherein the moving layers are inverted and wrapped around the stationary layers.

P

Parity: see Crease assignment.

Path: a line between two leaf vertices in the crease pattern.

Path conditions: the set of all inequalities relating the coordinates of the leaf vertices, the distances between their corresponding nodes, and a scale factor. The distance between any two vertices must be greater than or equal to the scaled distance between their corresponding nodes as measured along the tree.

Petal fold: a combination of two squash folds in which a corner is lengthened and narrowed.

Pseudohinge crease: a hinge crease in a uniaxial base whose projection is not a node of the underlying tree.

Plane of projection: a plane containing the axis of the base and the axial edges of all flaps, and that is perpendicular to the layers of the base.

Plan view: a model is folded in plan view if when it lies flat you are looking at the top of the subject.

Pleat fold: a fold formed by two parallel or nearly parallel mountain folds and valley folds formed through all layers of a flap.

Pleat grafting: adding one or more pleats that run across a crease pattern in order to add features or textures formed by the intersections of the pleats.

Plug: a crease pattern that is used to fill in holes in box-pleated patterns.

Precreasing: folding and unfolding to create the creases required for a (usually complex) step or an entire base.

Point-splitting: any of a variety of techniques for folding a single flap so that it turns into two or more (smaller) flaps.

Preliminary Fold: a traditional base formed by bringing the four corners of the square together.

Pythagorean stretch: a technique in box pleating in which two diagonally-oriented leaf vertices are allowed to move closer to each other than the square packing would normally permit. This results in the creation of axial creases and ridgeline creases at angles other than 0° , 45° , and 90° in the vicinity of the stretch but permits greater efficiency in the crease packing.

Q

R

Rabbit-ear fold: a way of turning a triangular corner into a flap, consisting of folding along all three angle bisectors of the triangle and gathering the excess paper into a flap.

Rabbit-ear molecule: the pattern of creases within a triangle that collapses its edges to lie on a single line.

Raw edge: the original edge of the paper, as opposed to an edge created by folding.

Reduced path: a path between two inset vertices created during the construction of the universal molecule.

Reduced path inequality: an inequality condition analogous to the path condition that applies to inset vertices and paths in the universal molecule.

Reverse fold: a way of changing the direction of a flap by folding different layers of the flap in different directions. The two most common forms are the inside reverse fold and the outside reverse fold.

Ridgeline crease: a crease within a molecule that propagates inward from the corners of the molecule. Ridgeline creases are always valley folds when viewed from the interior of a molecule.

River: a usually-curved or rectangular constant-width region in a tile or crease pattern that creates a segment between groups of flaps in the folded form.

S

Sawhorse molecule: a crease pattern within a quadrilateral similar to the Waterbomb molecule, but with a segment separating the two pairs of flaps. Also known as the Maekawa molecule.

Scale: a quantitative measure of efficiency. The scale of a crease pattern is the ratio between the length of a folded flap and the length of its corresponding edge in the tree graph.

Shaping: the folds that transform an abstract, geometric base into the finished figure.

Side view: a model is folded in side view if when the model lies flat you are looking at the side of the subject.

Sink fold: inversion of a point. Sink folds come in several different types.

Splitting points: see point-splitting.

Spread sink fold: a sink fold in which the edges of the point are spread and the point flattened. Similar to a squash fold.

Square/river packing: the analog of circle and river packing that allows box-pleated crease patterns.

Squash fold: a fold in which the edges of a flap are spread, usually symmetrically, and the edges flattened.

Standard bases: the most common origami bases, usually taken to include the Classic Bases plus the Windmill Base, Cupboard Base, Preliminary Fold, and Waterbomb Base.

Stretched Bird Base: a form of the Bird Base in which two opposite corners are pulled apart to straighten out the diagonal that connects them.

Strip graft: modifying a crease pattern as if you spliced in one or more strips of paper running across a crease pattern in order to add features to the base.

Stub: a new edge added to the tree graph attached to a new node introduced into the middle of an existing edge and associated creases added to the crease pattern. Adding a stub allows four path conditions to be simultaneously satisfied as equalities.

Subbase: a portion of a base, usually consisting of a single axial polygon.

Subtree: the tree graph that is the projection of a subbase.

Swivel fold: an asymmetric version of a squash fold in which the two valley folds are not collinear.

T

Tangent points: points along axial polygons where circles (or rivers) touch each other and are tangent to the hinge creases.

Technical folding: origami designs that are heavily based on geometric and mathematical principles.

Three-step model: a universal description of the general folding sequence for a model designed by technical folding. The three steps are: (1) precreasing; (2) collapse; (3) shaping.

Tile: a portion of a crease pattern, usually consisting of one or more axial polygons and decorated by circles and rivers, that can be assembled into crease patterns by matching circle and river boundaries.

Tree: short for tree graph.

Tree graph: a stick figure that represents a uniaxial base, in which each edge of the tree represents a unique flap or connection between flaps.

Tree theory: the body of knowledge that describes the quantitative construction of crease patterns for uniaxial bases based on a correspondence between features of a tree graph and features in the crease pattern.

Tree theorem: the theorem that establishes that satisfying the path conditions is both necessary and sufficient for the construction of a crease pattern for a given tree graph.

Triangulation: the process of decomposing high-order axial polygons in a crease pattern into smaller polygons that are all order-3, i.e., triangles.

U

Unfold: removing a valley fold or mountain fold (or a group of same), leaving behind one or more creases.

Uniaxial base: a base in which all flaps lie along a single axis and all hinges are perpendicular to the axis.

Universal molecule: a generalization of the gusset molecule that can be applied to every valid axial polygon.

Unsink: removing a sink fold, or turning a closed sink fold from concave to convex.

V

Valley fold: a crease that is concave upward. Usually indicated by a dashed line in sequential folding diagrams and a dashed or colored line in crease patterns.

Vertex: a point in a crease pattern where multiple creases come together. See leaf vertex, branch vertex.

W

Windmill Base: a traditional base that looks like a windmill.

Waterbomb Base: a traditional base formed by bringing the midpoints of the four edges of a square together.

Waterbomb condition: a quadrilateral satisfies the Waterbomb condition if and only if the sums of opposite sides are equal. A quadrilateral that satisfies this condition can be folded into an analog of the traditional Waterbomb Base.

Waterbomb molecule: a crease pattern within a quadrilateral that resembles the traditional Waterbomb. Also called the Husimi molecule.

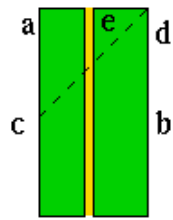
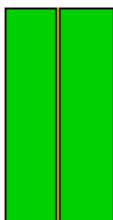
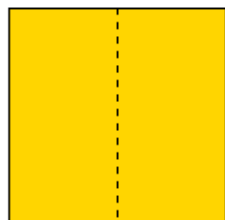
X

Y

Yoshizawa split: a technique for splitting a Kite Base flap, in which the point is first sunken, followed by two spread sinks.

Z

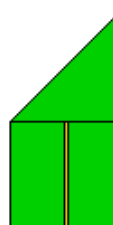
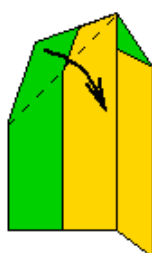
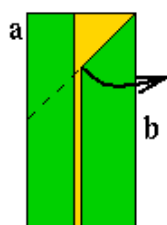
From paper yellow on one side, green on the other,
make a crease in the center.....fold edges to center....



make crease from c to d by folding
point a to meet b
then open out to
step 3 again.



Fold point e (shown in step 3)
under, along the diagonal fold:

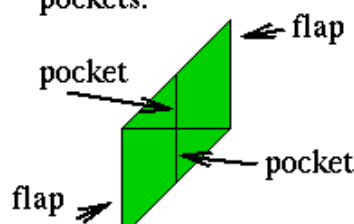


Next the left hand flap, the diagonal, under the
from a, will be folded along right hand flap:

Repeat with the other end, folding the
right hand lower flap under the left hand
flap, folding along a diagonal crease:



The finished unit has
two flaps and two
pockets:



Make two additional
diagonal creases:



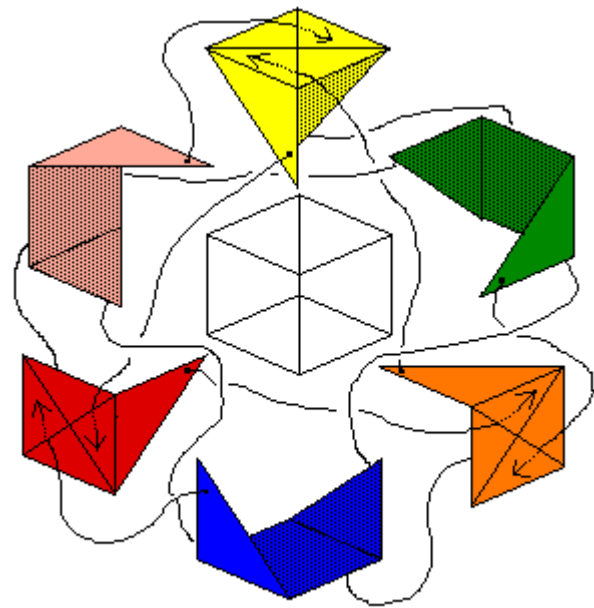
Basic Unit/Cube

The Units

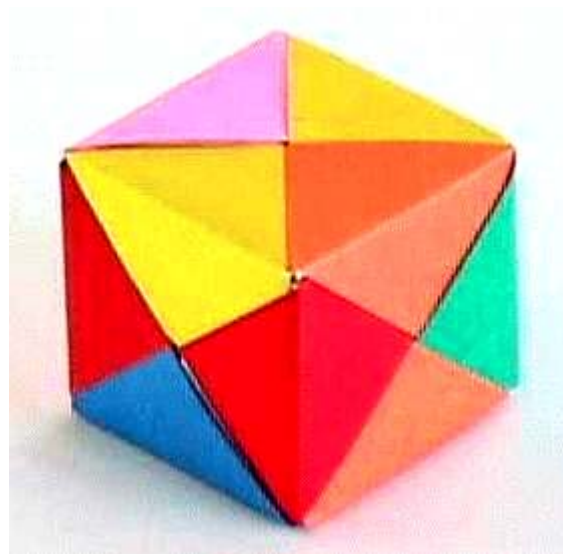
To make the Sonobe Cube, six identical units must be folded. It is important to do all the folds the same way. Reversing/mirroring step three will change the unit so that it will not fit with the others. After identically folding the six units required, fold one more unit and mirror step three by making the corner folds on the opposite corners and continuing on with the folds. You will find that this unit will, in no way, fit properly with the other six units you have folded.

The Assembly

About the only thing to note here is that the units are at right angles to each other. I hope this drawing gives enough detail into the assembly. It is so much easier to be shown this in real space.



The Basic Sonobe cube



Mathematical Instructions for Sonobe Cube Unit

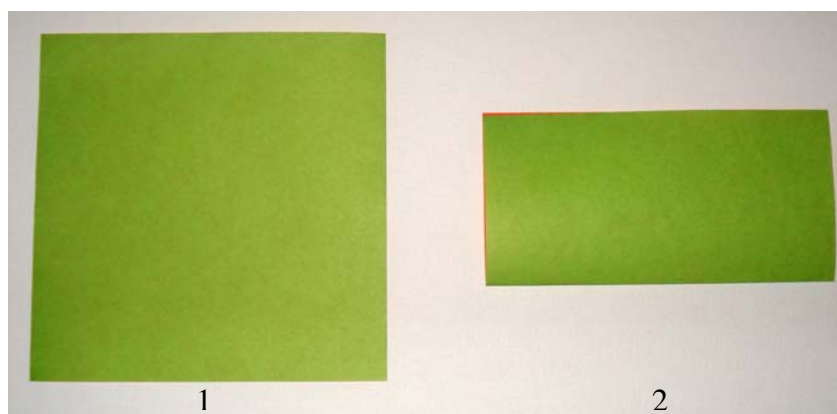
1. Start with a square.
2. Fold in half. This fold is a midsegment of the square. Unfold.
3. Fold top side down to midsegment. Do not unfold.
4. Fold bottom side up to midsegment. Do not unfold.
5. Fold lower left vertex to top side to create a trapezoid.
6. Spin (turn 180 degrees).
7. Fold lower left vertex to create a parallelogram.
8. Unfold to original square.
9. Fold vertices of upper left and lower right corners to the closest parallel quarter segment.
10. Fold lower side up to lower quarter segment.
11. Fold top side down to upper quarter segment.
12. Fold lower left vertex up to upper quarter segment.
13. Scrunch fold.
14. Spin (rotate 180 degrees).
15. Fold lower left vertex up under top flap (create a parallelogram with two folded rectangles in the middle).
16. Flip over.
17. Fold lower right and upper left vertices to create a square.

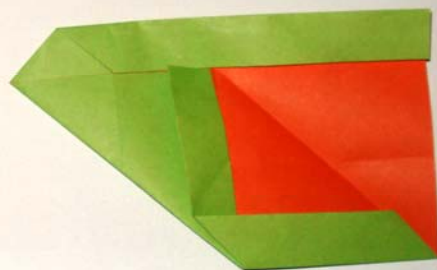
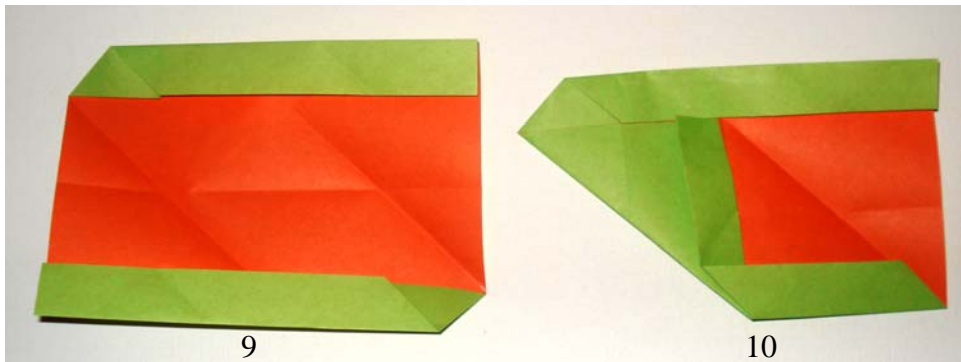
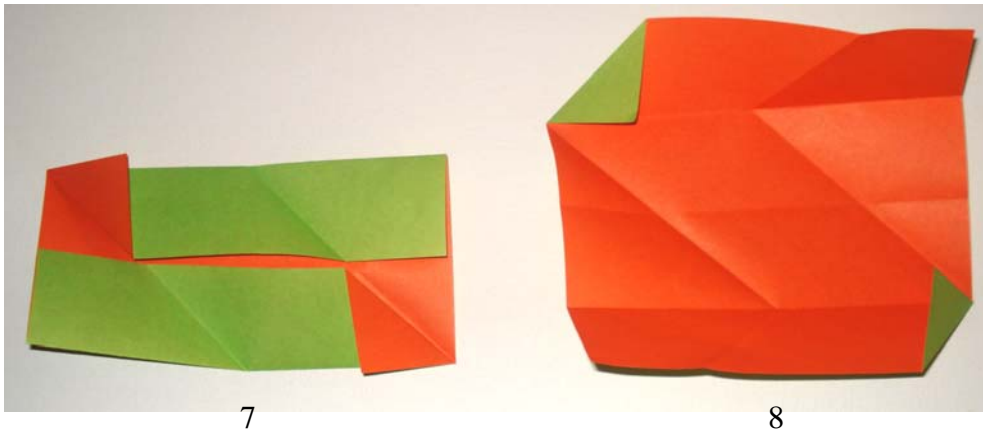
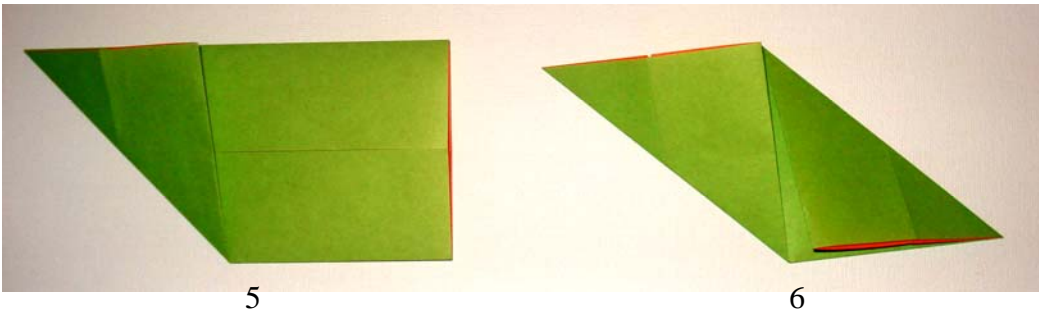
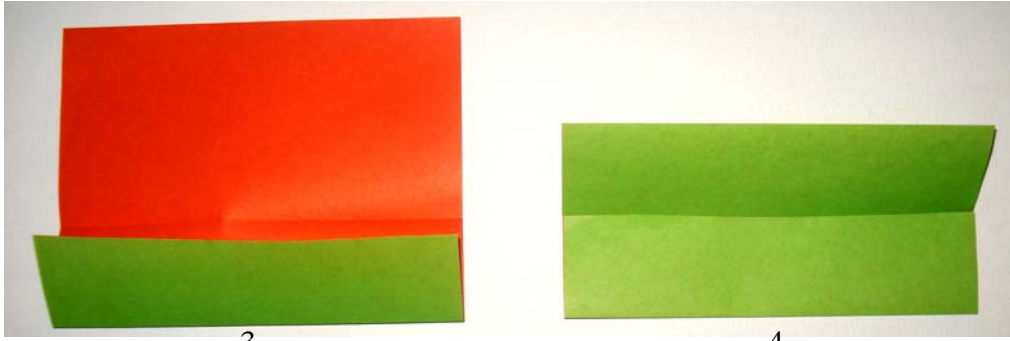
You have now created a Sonobe Unit. Create 6 units to make a Sonobe Cube. Fit each of the six units together keeping the units at right angles to each other.

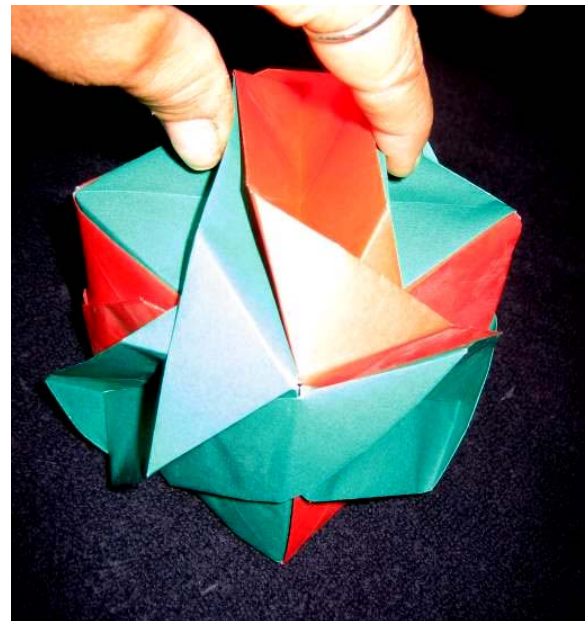
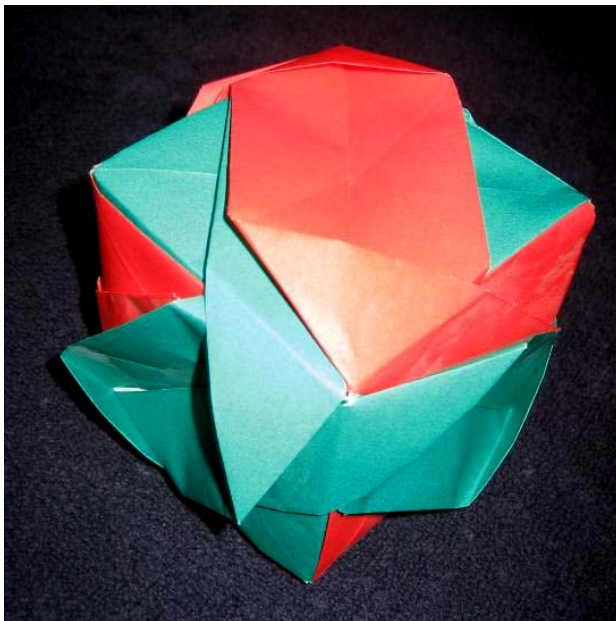
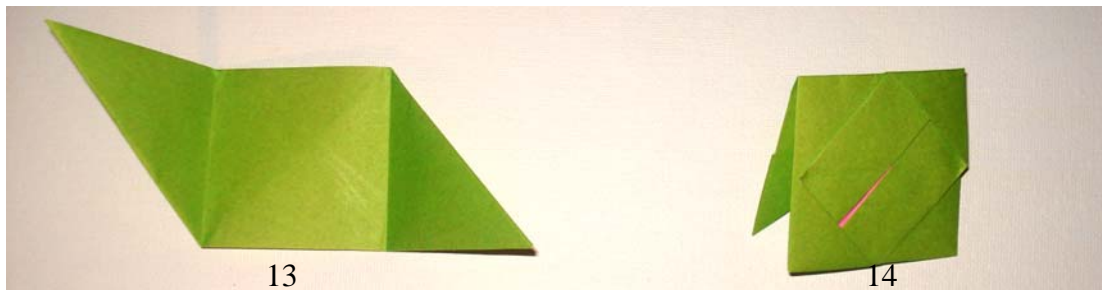
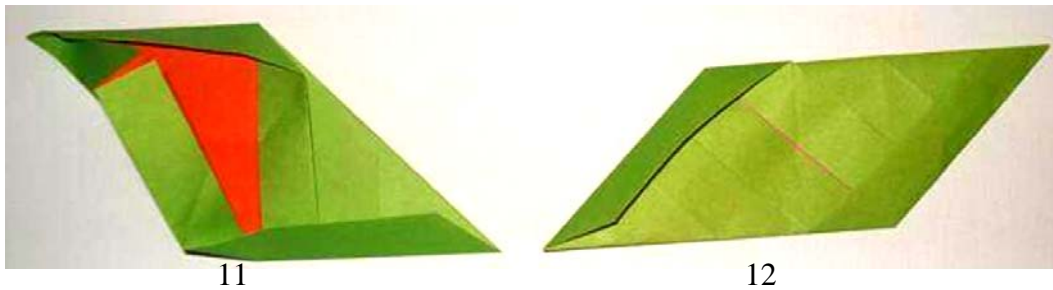
Sonobe Unit



The photo above is taken of a variation of a Sonobe cube, an advanced unit. What follows is a step-by-step pictorial guide to creating one.







After inserting each of the tabs of all 6 pieces into their pockets, (don't leave any on the inside), you will have a cube. Next, pull the scrunch folded centers out and away from the centers of each side of the cube. Do this on each of the six sides to create a beautiful stellated Sonobe unit. If your folds are accurate and crisp, it will be very strong and will hold together beautifully. Have fun, and try different forms.